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# WOODY PLANT TRIALS AT SIX MINE RECLAMATION SITES IN WYOMING AND COLORADO

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## ABSTRACT

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Select, hardy, and adaptable woody plant clones were vegetatively propagated. A higher percentage of softwood than hardwood cuttings rooted. Intermittent mist and rooting hormones were used on the cuttings. After 2 or 3 years, transplants of 85 woody and 2 forb species, at five surface-mined reclamation sites in Wyoming and one in Colorado, showed high survival percentages except at Kemmerer and Hanna, Wyo. None were irrigated.

The study showed that woody shrub plantings may survive a wide range of climatological and soil conditions but that growth of most species was slow and hindered by wildlife use. Antelope (*Antilocapra americana*) were particularly destructive of the test plants at the Shirley Basin and Hanna sites. Species showing the least amount of browse by antelope were: silver sagebrush (*Artemisia cana*), fourwing saltbush (*Atriplex canescens*), Maximowicz peashrub (*Caragana maximowicziana*), pygmy peashrub (*Caragana pygmaea*), Siberian salttree (*Halimodendron halodendron*), Chinese wolfberry (*Lycium chinense*), matrimonyvine (*Lycium halimifolium*), and trumpet gooseberry (*Ribes leptanthum*).

KEYWORDS: direct seeding, plant communities, plant  
ecosystems, plant propagation, plant trials, revegetation,  
rooting trials, soils characteristics,  
strip mining, surface mining

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## WOODY PLANT TRIALS AT SIX MINE RECLAMATION SITES IN WYOMING AND COLORADO<sup>1</sup>

By Gene S. Howard, Frank Rauzi, and Gerald E. Schuman<sup>2</sup>

### INTRODUCTION

Native woody plants in the plains and foothills of the northern Rocky Mountain States consist of relatively few species in any particular area; however, the benefits of woody plants in rangeland ecosystems are well recognized, whether they are used for browse, snow trapping, wildlife habitat, or esthetic appeal. These trials, using both native and introduced species, were initiated in response to the need for determining adaptable species for disturbed land revegetation. Such species not only need to be adapted to climatic conditions of various sites, but must also be able to survive wildlife and domestic livestock use.

May et al.<sup>3</sup> summarized their research with five woody species planted at the Kemmerer Coal Mine in southwestern Wyoming. They used four sites on 14-year-old spoils. They concluded that the adaptability, in order by species, was Russian olive (*Elaeagnus angustifolia*), Siberian peashrub (*Caragana arborescens*), and Siberian elm (*Ulmus pumila*). Red cedar (*Juniperus virginiana*) and skunkbush sumac (*Rhus trilobata*) had poor survival at all sites.

Swanson<sup>4</sup> listed the survival of 19 woody species at seven high-altitude sites in Colorado after the first growing season. Thirteen of his genera and four of his species were the same as the ones we used. *Elaeagnus angustifolia* was the only species included in those tested by May et al. Survival was high for most of Swanson's species; however, winter survival was not tested.

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<sup>3</sup>May, M., Lang, R., Lujan, L., and others. Reclamation of strip mine spoil banks in Wyoming. Wyo. Agr. Expt. Sta. Res. Jour. 51, 32 pp. 1971.

<sup>4</sup>Swanson, B.T. Acclimation of trees and shrubs to high altitudes. Colo. State Univ., Proceedings of the High Altitude Revegetation Workshop No. 2, Inf. Series 21, pp. 54-57. 1976.

## SITE DESCRIPTIONS

Sites for shrub planting were selected to represent a wide range of soils, plant ecosystems, and climatic factors. The Soil Conservation Service and several mining companies requested assistance. These requests became additional criteria for site selection. All sites were on surface-mined reclamation areas. Plantings were made on overburden that had been replaced and graded to acceptable contours and then covered with stockpiled or newly stripped topsoil to a depth of 6 to 18 inches, except at Hanna and on one-half of the study at Oak Creek where no topsoil was replaced.

Site names, locations (nearest town), and elevations were as follows:

Wyodak Resources Development Corp. (coal mine)	
Gillette, Wyo.	4,500 ft
Pacific Power & Light Co.	
Dave Johnson Coal Mine, Glenrock, Wyo.	6,000 ft
Lucky Mac Uranium Corp. (uranium mine)	
Shirley Basin, Wyo.	7,200 ft
Rosebud Coal Sales (coal mine)	
Hanna, Wyo.	7,200 ft
Kemmerer Coal Co. (coal mine)	
Frontier, Wyo.	7,600 ft
Pittsburg & Midway Coal Co. (coal mine)	
Oak Creek, Colo.	7,500 ft

Annual and average precipitation at each site are as follows:

Site	1975	1976	1977	Average annual
-----Centimeters-----				
Gillette	<sup>1</sup> 41.66	43.05	48.90	38.43
Glenrock	29.74	34.52	36.88	33.76
Shirley Basin (Rawlins) <sup>2</sup>	23.52	15.14	24.97	29.46
Hanna	--	25.53	28.58	27.05
Kemmerer	23.55	19.18	15.24	23.52
Oak Creek (Yampa) <sup>2</sup>	39.57	40.46	40.49	40.17

<sup>1</sup>Precipitation data taken from 1975, 1976, and 1977, U.S. Department of Commerce Summaries of Climatological Data for Wyoming and Colorado, except for Hanna, which is our record taken on site.

<sup>2</sup>Station nearest test location.

Precipitation data for stations nearest test locations were used to represent the Shirley Basin and Oak Creek sites. A majority of the precipitation

falls during the growing season (May to October) at all sites except Oak Creek, which has more nearly uniform monthly precipitation throughout the year.

## ORIGINAL PLANT COMMUNITIES OF THE TEST SITES

The Gillette and Glenrock sites have a potential native plant community of about 75 percent grasses or grasslike plants, 15 percent forbs, and 10 percent woody plants. The major species are: western wheatgrass (*Agropyron smithii-molle*), needleandthread grass (*Stipa comata*), blue grama grass (*Bouteloua gracilis*), green needlegrass (*Stipa viridula*), sandberg bluegrass (*Poa secunda*), American vetch (*Vicia americana*), fringed sagewort (*Artemisia frigida*), and big sagebrush (*Artemisia tridentata*).<sup>5</sup>

The potential native plant community at the Shirley Basin site is about 75 percent grasses and grasslike species, 10 percent forbs, and 15 percent woody species. Major species are: western wheatgrass, bluebunch wheatgrass (*Agropyron spicatum*), needleandthread grass, blue grama grass, threadleaf sedge (*Carex filifolia*), fringed sagewort, and big sagebrush.

The Hanna site has a potential native plant community of about 75 percent grasses and grasslike species, 10 percent forbs, and 15 percent woody species. Major species are: western wheatgrass, thickspike wheatgrass (*Agropyron dasystachyum*), bottlebrush squirreltail (*Sitanion hystrix*), needleandthread grass, sandberg bluegrass, fringed sagewort, and rabbitbrush (*Chrysothamnus* sp.).

At Kemmerer, the potential native plant community is about 75 percent grasses and grasslike species, 10 percent forbs, and 15 percent woody species. Major species are: western wheatgrass, needleandthread grass, bluebunch wheatgrass, bottlebrush squirreltail, Indian ricegrass (*Oryzopsis hymenoides*), basin wildrye (*Elymus cinereus*), big sagebrush, shadscale (*Atriplex confertifolia*), rabbitbrush, nuttall saltbush (*Atriplex nuttalli*), winterfat (*Ceratoides lanata*), saskatoon serviceberry (*Amelanchier alnifolia*) and snowberry (*Symphoricarpos albus*).

The Oak Creek site is a mixed shrub plant community. Dominant species are: saskatoon serviceberry, gambels oak (*Quercus gambeli*), quaking aspen (*Populus tremuloides*), big sagebrush, snowberry, chokecherry (*Prunus virginiana*), and mountain brome grass (*Bromus marginatus*).

## SOIL CHARACTERISTICS

Soil pH, electrical conductivity, texture, and organic matter were determined on the topsoil and subsoil material at each of the sites. This information is shown in table 1. In most cases, the subsoil material is a mixture of overburden and the original subsoil material. In general, the characteristics

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<sup>5</sup>Plant community classifications were furnished by personnel of the Soil Conservation Service at the respective sites.

TABLE 1.--Soil characteristics at 6 mine reclamation sites

Location and soil association	Soil material	pH	Texture	Electrical conductivity	Organic matter
				<i>mmhos/cm</i>	<i>Percent</i>
Lucky Mac Uranium Corp. Shirley Basin, Wyo. (Borollic Haplargid)	Topsoil Subsoil <sup>1</sup>	7.2 7.8	Sandy loam --do--	0.78 .95	1.68 .58
Pacific Power & Light Co. Dave Johnson Mine Glenrock, Wyo. (Ustollic Haplargid)	Topsoil Subsoil	6.3 5.2	--do-- --do--	1.18 4.20	21.25 2.00
Wyodak Mine Gillette, Wyo. (Ustollic Haplargid)	Topsoil Subsoil	6.9 6.7	Clay loam --do--	3.98 1.60	4.32 3.30
Kemmerer Coal Co. Frontier, Wyo. (Ustic Torriorthent)	Topsoil Subsoil	7.3 8.0	--do-- Silt loam	.40 3.10	3.00 .80
Rosebud Coal Sales Hanna, Wyo. (Borollic Haplargid)	Topsoil <sup>3</sup> Subsoil	--- 7.4	--- Silt loam	--- 7.02	--- 2.87
Pittsburg & Midway Coal Co. Oak Creek, Colo. (Unnamed complex)	Topsoil Subsoil	7.4 7.7	--do-- Clay loam	2.00 3.30	6.50 3.70

<sup>1</sup>Mixture of spoils and other subsoil material.<sup>2</sup>Reclaimed soils at the coal mine sites have various amounts of coal particles, which contribute to the high organic matter readings in some samples.<sup>3</sup>No topsoil replaced on this site.

of the soil material of the sites were not detrimental to plant growth except at the Hanna site where no topsoil was placed over the spoil and the soluble salts were quite high. The plants were fertilized each year with a mixture of ammonium nitrate and treble superphosphate.

## MATERIALS AND METHODS

The woody plant trials were begun in 1975 at three sites using propagated plant material of species then available at the High Plains Grassland Research Station (formerly the Cheyenne Horticultural Field Station). Additional clones of woody plant species, from the worldwide collections made by personnel of the Cheyenne Station over a 46-year span, were propagated to expand the 1975 trials and to include three additional sites in 1976, with the Oak Creek site having two separate studies.

Plants of all species tested except one were successfully propagated by the use of hardwood and softwood cuttings under intermittent mist (table 2). Neither the hardwood nor softwood cuttings were stored but were placed directly into the propagating bench. The lower one-third of each cutting stem was sprayed with liquid rooting hormones prior to being placed in the perlite rooting medium. The hormone formula used was 1 g indole-3-butyric acid and 0.625 g 1-naphthaleneacetic acid dissolved in 125 ml of ethanol and brought to 500-ml volume with distilled water. One gram of a wettable fungicide was added to the solution to control fungi.

TABLE 2.--Rooting data for cuttings of woody plants

Date set in rooting bench	Class of cuttings <sup>1</sup>	Cuttings of each species	Species tested <sup>2</sup>	Species rooted	Rooting range	Average of species rooted
		Number	Number	Number	Percent	Percent
2-21-74	Hardwood	50	46	29	2-82	24.8
7-02-74	Softwood	50	25	24	2-100	63.2
6-10-75	--do--	50	27	26	8-100	60.4
	--do--	20-49	12	12	19-100	64.8
	--do--	10-29	18	18	4-100	56.5
6-23-76	--do--	90-100	6	6	7-68	44.5
	--do--	50	18	18	6-100	57.9
	--do--	30-49	2	2	36-95	65.5
	--do--	10-29	3	3	60-100	86.7

<sup>1</sup>All cuttings were sprayed with rooting hormone before being placed in rooting media.

<sup>2</sup>Species not mutually exclusive.

After rooting, plants were either potted in a greenhouse potting soil mix in 15-lb tar paper containers, 2-3/4 by 2-3/4 by 9 inches, or set in a nursery row in a lathhouse. Plants propagated and set in containers in the summer of 1975 were induced to go dormant for 45 days in late fall under shade and cold temperatures. They were then forced into a winter growth cycle under extended day length and warm temperatures for 90 days to obtain larger plants for field planting in 1976. This treatment was followed by a second dormant cycle of at least 6 weeks prior to field planting in May and June 1976. All plants under trial were transplanted to the field in the spring months of April, May, or June.

Trial plants at all sites were set in rows, with 3 to 8 ft between plants in the row and 20 to 25 ft between rows. Shrubs were planted at the closer spacings. Plantings were made in 1975, 1976, and 1977.

Sites at Gillette, Glenrock, and Shirley Basin were cultivated while the other three sites were planted and left to compete with the plants of natural succession. Plantings at the Shirley Basin, Hanna, and Kemmerer sites were watered when set in the field. All plants were container grown except for the bare root plants keyed in table 3.

Plant growth and survival notes were taken in late September each year. Height was recorded the first 2 years, and both height and spread were recorded in 1977 as the measure of growth. Notes on wildlife use were taken in 1976 and 1977 and are discussed in the conclusions. Only the 1977 growth and survival data are published in table 3.

In addition to the species summarized in table 3, 13 species were direct seeded at two locations in the fall of 1976 using a cone seeder (table 4). Eight species were direct seeded with a cone seeder at the same locations in the spring of 1977.

## RESULTS AND DISCUSSION

Table 2 summarizes rooting trials for hardwood and softwood cuttings. The variable numbers of cuttings used after 1974 reflect our desire to establish specific numbers of plants of each species. The rooting of 44.5 percent of the six species rooted in 1976 reflects the use of some of the more difficult species to root. Average percentage of rooting for all species was 61 percent.

Growth and survival for 85 woody and 2 forbs species are summarized in table 3. Ages of plantings may be obtained by counting growing seasons, including the year shown in the year set column. Summaries are listed in separate columns for each of the six planting sites. They show the topsoiled and overburden plots separately at Oak Creek. All species shown were not planted at each site; therefore, species without data at any site were not planted. Four species were planted for the first time in 1977; hence, they only show planting survival and first season growth in table 3.

Establishment losses, the first season after planting, listed by sites were 8 of 62 species at Gillette, 3 of 69 species at Glenrock, 1 of 61 species at

Shirley Basin, 5 of 20 species at Hanna, 1 of 49 species at Kemmerer, and none at Oak Creek. Later losses indicate environmental stress from weather, soils, wildlife, or other causes.

The results of direct seeding 13 species in the fall and 8 species in the spring are shown in table 4. *Artemisia vulgaris* and two species of *Caragana* at Shirley Basin and six species of *Caragana* at Glenrock produced plants from direct fall seeding. Only two *Caragana* species at Glenrock produced plants from direct spring seeding.

In addition to small numbers of rabbits (*Lepus* sp.) at all sites, wildlife browse of plant species at Gillette was by mule deer (*Odocoileus hemionus*) and antelope (*Antilocapra americana*), at Glenrock mostly by mule deer, at Shirley Basin and Hanna mostly by large populations of antelope, at Kemmerer mostly by mule deer, and at Oak Creek by mule deer and elk (*Cervus canadensis*).

### CONCLUSIONS

This study shows that woody shrub plantings may survive climatological and soil conditions and the browse of all wildlife species except antelope when planted under these conditions. Antelope have eaten all the test species to ground level except those species with natural protective mechanisms; however, if shrub species were planted in forage mixtures so they would be widely dispersed over large acreages, wildlife use might be considerably different. This approach is now being tested and evaluated.

At Shirley Basin and Hanna, those species with natural protective mechanisms limiting antelope browse were the pygmy forms of *Caragana* (Maximowicz peashrub and pygmy peashrub), fourwing saltbush, Siberian salttree, matrimony-vine, Chinese wolfberry, and trumpet gooseberry. Silver sagebrush was the most browse resistant of the *Artemisia* species tested. Protective mechanisms were in the form of thorns, volatile oils, and flavor.

Additional species that show the most promise for surface mined land revegetation may be found by reference to table 3. Those species with a high percentage survival and comparative good growth at the different sites may be used. *Caragana* species, which will grow from direct seeding, are recommended. The species of *Artemisia*, and particularly *A. vulgaris* because of its nutritive value and ability to withstand grazing, appear well adapted. The species of *Cotoneaster*, *Juniperus*, *Lonicera*, and *Rhamnus* may be used when transplants are available. The species of *Cotoneaster* are particularly drouth resistant and adapted to clay soils.

TABLE 3.--Woody plant species, planting locations, and growth  
topsoil and on overburden at

Year set	Botanical name	Common name	Gillette		
			Ht. <sup>1</sup>	Spr.	Surv.
			Cm	Cm	%
1975 <sup>2</sup>	<i>Achillea filipendulina</i>	Fernleaf yarrow <sup>3</sup>	47	70	50
1976 <sup>4</sup>	<i>Amorpha fruticosa</i>	Indigobush amorpha	61	42	67
1975	<i>Artemisia abrotanum</i>				
	subsp. <i>nanum</i>	Dwarf oldman wormwood	28	66	100
1976	<i>A. absinthium</i>	Common wormwood			
1976	<i>A. cana</i>	Silver sagebrush	26	27	100
1975	<i>A. tridentata</i>	Basin big sagebrush			
1975	<i>A. vulgaris</i>	Mugwort wormwood	56	39	100
1976	<i>Atraphaxis frutescens</i>	( <sup>5</sup> )			
1976	<i>Atriplex canescens</i>	Fourwing saltbush	42	94	100
1975	<i>Caragana arborescens</i>	Siberian peashrub <sup>3</sup>	72	35	93
1976	<i>C. boisii</i>	Bois peashrub	61	24	80
1976	<i>C. decorticans</i>	Afghanistan peashrub	33	19	100
1977	<i>C. fruticosa</i>	Shrubby peashrub	38	21	100
1977	<i>C. maximowicziana</i>	Maximowicz peashrub	19	40	80
1976	<i>C. microphylla</i>	Littleleaf peashrub			
1977	<i>C. pekinensis</i>	Peking peashrub	36	22	100
1976	<i>C. pygmaea</i>	Pygmy peashrub	21	25	100
1975	<i>Celtis occidentalis</i>	Hackberry <sup>3</sup>	--	--	0
1975	<i>Ceratoides lanata</i>	Winterfat	17	26	60
1975	<i>Cercocarpus betuloides</i>	Birchleaf mountain mahogany <sup>3</sup>	--	--	0
1975	<i>Chrysothamnus nauseosus</i>	Rubber rabbitbrush	39	35	100
1975	<i>Cotoneaster acutifolia</i>	Peking cotoneaster <sup>3</sup>	38	46	100
1976	<i>C. multiflora</i>	( <sup>5</sup> )			
1976	<i>C. obtusa</i>	( <sup>5</sup> )			
1976	<i>C. racemiflora</i> var. <i>desfontainesii</i>	( <sup>5</sup> )			
1976	<i>C. tomentosa</i>	Brickberry cotoneaster			
1976	<i>C. sp.</i> (P.I. 113097)		20	14	100
1976	<i>Crataegus rivularis</i>	River hawthorn			
1975	<i>Elaeagnus angustifolia</i>	Russian olive <sup>3</sup>	29	18	90
1976	<i>E. commutata</i>	Silverberry	11	11	33
1976	<i>Forestiera neomexicana</i>	Desert olive	14	8	67
1975	<i>Fraxinus pennsylvanica</i>	Green ash <sup>3</sup>	37	11	75
1976	<i>Halimodendron</i>				
	<i>halodendron</i>	Siberian salttree	23	45	100
1975	<i>Juniperus monosperma</i>	Singleseed juniper			

See footnotes at end of table.

and survival data taken at the end of the 1977 growing season. Plantings on Oak Creek, Colo., are listed separately

Glenrock			Shirley Basin			Hanna			Kemmerer			Oak Creek			Oak Creek		
Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.		
Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%
63	73	100															
35	39	100	3	4	67				--	--	0						
35	59	100	16	22	67	9	7	50	--	--	0	18	32	75	29	54	75
37	44	100	12	16	100							32	24	50	47	55	100
22	32	100	8	10	100	--	--	0	4	9	20	21	21	75	23	29	50
--	--	0	12	19	33												
26	33	92	32	31	100	7	7	70	5	10	45	5	13	75	14	24	100
									6	8	60						
38	82	100	11	36	100	19	49	89	8	26	83	13	41	75	21	61	100
48	28	92	34	16	100				8	4	78	17	14	100	33	13	100
									9	7	50						
18	12	100	13	11	67				--	--	0	14	13	100	23	15	100
31	24	100															
16	14	100	14	22	100	11	17	100	11	12	80	11	15	100	15	21	100
16	11	25	--	--	0							11	6	100	6	8	100
31	37	92				12	20	13				11	19	50	--	--	0
--	--	0										7	5	25	10	9	25
30	33	67	5	8	100	12	13	42	4	7	57	36	38	75	29	33	50
32	25	92	8	14	100	2	2	100	5	6	44						
									--	--	0						
						9	3	75	6	7	25						
24	30	100	3	7	100							16	25	75	28	48	75
									2	8	17						
35	55	100	12	5	67				--	--	0	18	31	75	32	55	75
14	7	100	6	3	100												
55	78	83	13	14	100	13	8	40	--	--	0	27	22	100	37	41	100
8	8	100	14	7	100	--	--	0	--	--	0	--	--	0	13	11	25
34	25	100	2	2	33	5	4	33	--	--	0	23	10	75	10	9	75
13	5	42	--	--	0							30	6	100	31	8	100
37	77	100	27	60	100	17	20	100	--	--	0	25	29	100	35	20	100
16	16	75							18	15	10	11	14	100	17	18	100

TABLE 3.--Woody plant species, planting locations, and growth  
topsoil and on overburden at

Year set	Botanical name	Common name	Gillette		
			Ht. <sup>1</sup>	Spr.	Surv.
			Cm	Cm	%
1975	<i>J. scopulorum</i>	Rocky Mountain juniper	32	27	100
1975	<i>J. virginiana</i>	Eastern red cedar	28	40	67
1976	<i>Kochia prostrata</i>	Prostrate summer cypress	33	57	100
1976	<i>Lonicera bella</i>	Belle honeysuckle	29	36	100
1976	<i>L. korolkowii</i>	Blueleaf honeysuckle	23	56	100
1976	<i>L. maackii</i>	Amur honeysuckle	--	--	0
1976	<i>L. muendeniense</i>	Muenden honeysuckle	41	45	50
1976	<i>L. tatarica</i>	Tatarian honeysuckle <sup>3</sup>	30	32	100
1975	<i>L. tatarica</i> cv. <i>rosea</i>	Rose tatarian honeysuckle	23	21	33
1976	<i>Lycium chinense</i>	Chinese wolfberry	37	63	100
1976	<i>L. halimifolium</i>	Matrimonyvine	47	62	100
1975	<i>Malus</i> sp.--Hopa seedlings	( <sup>3</sup> <sup>5</sup> )	30	25	100
1976	<i>Physocarpus intermedius</i>	Illinois ninebark	19	12	60
1976	<i>Pinus aristata</i>	Bristlecone pine			
1975	<i>P. ponderosa</i>	Ponderosa pine	15	10	100
1975	<i>Populus angustifolia</i>	Narrowleaf cottonwood <sup>3</sup>	102	97	37
1976	<i>Potentilla farreri</i>	Farrer cinquefoil	--	--	0
1976	<i>P. fruticosa</i>	Bush cinquefoil	--	--	0
1976	<i>Prinsepia sinensis</i>	Prinsepia cherry			
1975	<i>Prunus tomentosa</i>	Nanking cherry <sup>3</sup>	22	10	33
1976	<i>Ptelea baldwinii</i>	Baldwin hoptree			
1976	<i>Quercus macrocarpa</i>	Burr oak	--	--	0
1976	<i>Rhamnus cathartica</i>	Common buckthorn	24	14	67
1976	<i>R. chlorophora</i>	( <sup>5</sup> )			
1976	<i>R. davurica</i>	Dahurian buckthorn	32	14	67
1976	<i>R. infectoria</i>	Persianberry buckthorn	25	6	63
1976	<i>R. tinctoria</i>	Dyers buckthorn			
1975	<i>Rhus trilobata</i>	Skunkbush sumac <sup>3</sup>	18	16	73
1976	<i>Ribes leptanthum</i>	Trumpet gooseberry	38	31	33
1975	<i>R. odoratum</i>	Clove currant <sup>3</sup>	27	31	25
1975	<i>Ribes</i> sp.	Gooseberry	20	21	11
1976	<i>Rosa arkansana</i>	Arkansas rose <sup>3</sup>	10	19	100
1975	<i>Salix</i> sp.	( <sup>3</sup> <sup>5</sup> )			
1975	<i>Shepherdia argentea</i>	Buffaloberry	34	19	86
1976	<i>Sorbaria sorbifolia</i> var. <i>stellipila</i>	Starry ural falsespirea			
1976	<i>Spiraea gemmata</i>	Mongolian spirea			
1976	<i>S. nipponica</i>	Nippon spirea	--	--	0
1976	<i>S. sargentina</i>	Sargent spirea	16	20	67

See footnotes at end of table.

and survival data taken at the end of the 1977 growing season. Plantings on Oak Creek, Colo., are listed separately--Continued

Glenrock			Shirley Basin			Hanna			Kemmerer			Oak Creek			Oak Creek		
Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.		
Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%
22	17	50	11	12	70							49	29	75			
42	27	93	15	12	80							49	35	75	45	37	100
			12	23	67												
20	17	20	7	11	83				--	--	0	21	18	75	16	38	100
16	22	80	11	13	80				--	--	0	20	40	100	29	49	100
15	25	67	4	13	50							--	--	0	10	14	75
25	22	80	11	12	100				9	16	8	23	27	75	30	41	100
36	28	100	9	11	100												
51	19	100	10	8	100				--	--	0	20	25	100	31	34	100
76	71	100	31	31	100				11	10	33	49	76	100	62	108	100
58	48	100	26	35	100	18	16	100	4	8	33	43	33	100	40	58	100
23	13	50															
			20	6	40	--	--	0	--	--	0	22	10	75	15	13	75
												21	17	100	14	15	100
16	10	67	12	4	90							12	7	100	11	9	100
33	44	75	2	2	11							22	19	75	26	40	100
18	10	33	5	7	67				--	--	0	--	--	0	--	--	0
12	12	33	5	6	33				--	--	0	--	--	0	15	11	25
--	--	0										7	5	50	--	--	0
21	26	25	6	2	40							20	13	50	13	9	100
									--	--	0						
6	4	33	--	--	0	--	--	0	--	--	0	8	5	50	5	3	75
21	17	100				--	--	0	--	--	0	10	12	100	15	18	100
22	21	100	4	4	88				--	--	0	15	12	75	19	19	75
35	23	100										18	14	75	16	15	75
			6	4	67				--	--	0	10	8	75	13	9	25
48	29	100	6	6	100							16	13	100	11	9	100
14	14	100							--	--	0	14	15	100	21	24	100
26	25	33	18	16	100				--	--	0	27	21	75	39	29	75
			5	7	8							28	13	100			
--	--	0	--	--	0												
7	19	100	5	8	100				4	5	25	10	18	50	9	22	100
23	5	100															
29	34	100	7	12	83							22	12	50	15	15	75
												13	11	25	18	13	75
21	21	100	11	12	100				--	--	0	20	19	50	18	27	75
21	19	40	4	6	50							13	29	25	7	11	50
29	21	100	6	5	100				--	--	0	18	19	100	13	19	100

TABLE 3.--Woody plant species, planting locations, and growth  
topsoil and on overburden at

Year set	Botanical name	Common name	Gillette		
			Ht. <sup>1</sup>	Spr.	Surv.
			Cm	Cm	%
1976	<i>S. wilsonii</i>	Wilson spirea	12	19	100
1976	<i>Symphoricarpos albus</i>	Common snowberry	18	17	100
1976	<i>S. oreophilus</i>	Mountain snowberry			
1976	<i>S. utahensis</i>	Utah snowberry			
1976	<i>S. vaccinioides</i>	Whortleaf snowberry			
1976	<i>Symphoricarpus</i> sp.	( <sup>5</sup> )	18	17	100
1976	<i>Syringa chinensis</i>	Chinese lilac			
1976	<i>S. japonica</i>	Japanese tree lilac	7	7	33
1976	<i>S. persica</i>	Persian lilac			
1975	<i>S. vulgaris</i>	Common lilac <sup>3</sup>	13	13	67
1977	<i>Tanacetum vulgare</i>	Common tansy <sup>3</sup>			
1975	<i>Ulmus pumila</i>	Siberian elm <sup>3</sup>	32	25	80
1976	<i>Viburnum burejaeticum</i>	Manchurian viburnum	--	--	0
1976	<i>V. lantana</i>	Wayfaring tree			
1976	<i>V. opulus</i>	Highbush cranberry	17	10	100

<sup>1</sup>Ht., Spr., and Surv. are height, spread, and survival, respectively.  
Dashes indicate plant did not grow; blank spaces indicate species was not  
planted.

<sup>2</sup>Generally, 8 to 12 plants of each species set in each location in 1975.

<sup>3</sup>Planted as bareroot stock.

<sup>4</sup>Generally, 3 to 5 plants of each species set in each location in 1976 and  
1977.

<sup>5</sup>No acceptable common names.

and survival data taken at the end of the 1977 growing season. Plantings on Oak Creek, Colo., are listed separately--Continued

Glenrock			Shirley Basin			Hanna			Kemmerer			Oak Creek			Oak Creek		
Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.			Ht.Spr.Surv.		
Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%	Cm	Cm	%
18	23	100	--	--	0				--	--	0	12	23	75	13	19	50
20	17	60	4	7	100	9	10	33	--	--	0	21	21	100	19	17	100
16	19	80	4	8	67							30	20	25	15	30	50
									--	--	0	32	35	100	45	86	100
						8	7	100									
41	33	100	11	9	67				--	--	0	17	18	75	40	39	50
33	32	100										11	12	75	17	14	100
9	9	67	3	3	67				--	--	0	9	9	75	8	7	75
28	20	100	6	3	33	2	2	50	--	--	0	18	18	50	10	8	75
21	17	100	6	7	58							13	15	100	10	11	100
									6	7	50						
22	27	92	17	13	80							49	20	100	30	24	100
6	11	33	--	--	0				--	--	0	9	9	25	6	13	75
10	10	33	--	--	0				--	--	0	8	12	50	--	--	0
--	--	0	--	--	0							--	--	0	--	--	0

TABLE 4.--Data for direct seeding of shrubs

Species	Shirley Basin		Pacific Power and Light (Glenrock)		
	Row length in feet	Stand in summer 1977	Row length in feet	Stand on 6-14-77	Stand on 9-22-77
	<i>Seeded 10-22-76</i>		<i>Seeded 10-22-76</i>		
<i>Artemisia abrotanum</i>	48	None	50	None	None
subsp. <i>nanum</i>					
<i>A. cana</i>	42	None	65	None	None
<i>A. tridentata</i>	44	None	50	None	None
<i>A. vulgaris</i>	45	Fair <sup>1</sup>	45	None	None
<i>Caragana arborescens</i>	38	Fair	50	Fair	Few <sup>2</sup>
<i>C. aurantiaca</i>	24	Fair	52	None	Few
<i>C. boisii</i>	33	None	58	Fair	Few
<i>C. decorticans</i>	28	None	40	Few	Fair
<i>C. fruticosa</i>	33	None	56	Many <sup>3</sup>	Many
<i>C. microphylla</i>	36	None	52	Many	Many
<i>Cotoneaster acutifolia</i>	28	None	45	None	None
<i>C. multiflora</i>	21	None	54	None	None
<i>C. racemiflora</i>	28	None	40	None	None
<i>soongorica</i>					
	<i>Seeded 4-21-77</i>		<i>Seeded 4-28-77</i>		
<i>Artemisia vulgaris</i>	20	None	20	None	None
<i>Caragana arborescens</i>	22	None	30	None	None
<i>C. aurantiaca</i>	20	None	24	None	None
<i>C. boisii</i>	24	None	25	None	Few
<i>C. maximowicziana</i>	22	None	20	None	None
<i>C. pekinensis</i>	22	None	48	Fair	Fair
<i>Cercocarpus</i>	24	None	42	None	None
<i>douglasi</i>					
<i>Pinus ponderosa</i>	22	None	78	None	None

<sup>1</sup>Fair, about 5 to 8 plants per 16 ft of row.

<sup>2</sup>Few, about 1 to 3 plants per 16 ft of row.

<sup>3</sup>Many, 16 or more plants per 16 ft of row.